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Title

Automation of Ecological River Design: Opportunities and Challenges

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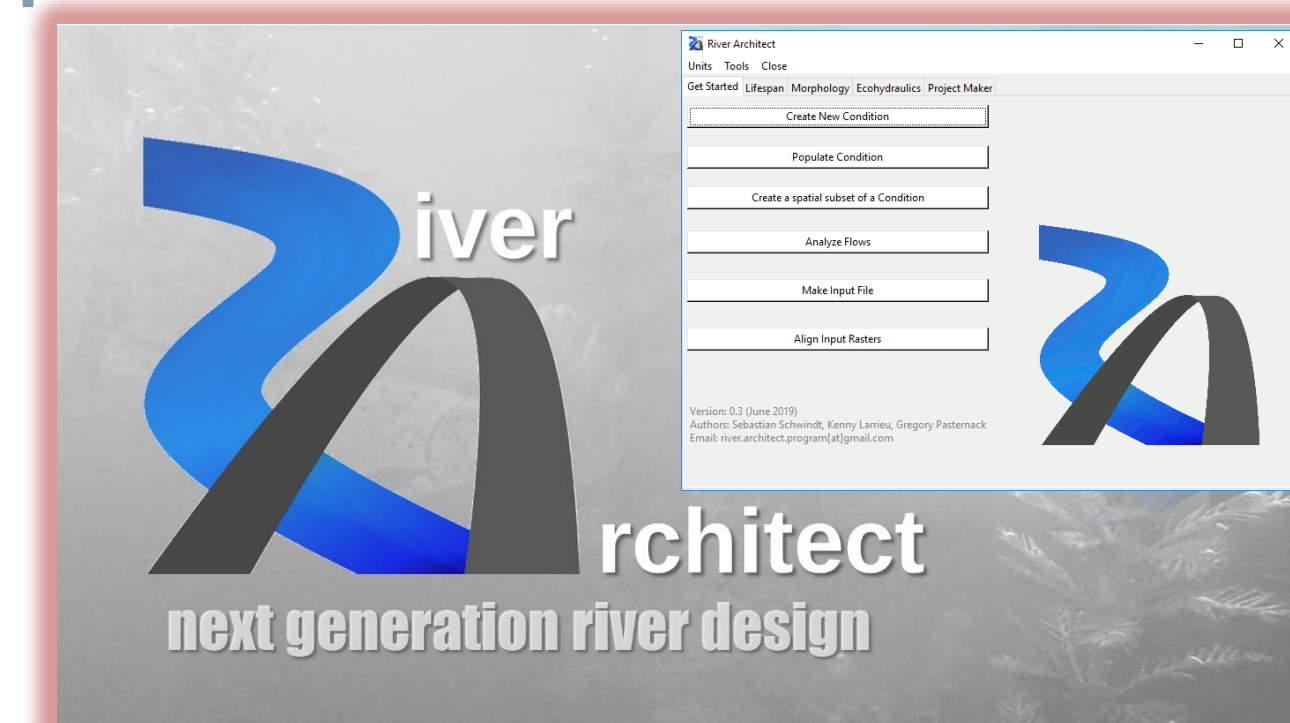
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INTRODUCTION & METHODOLOGY

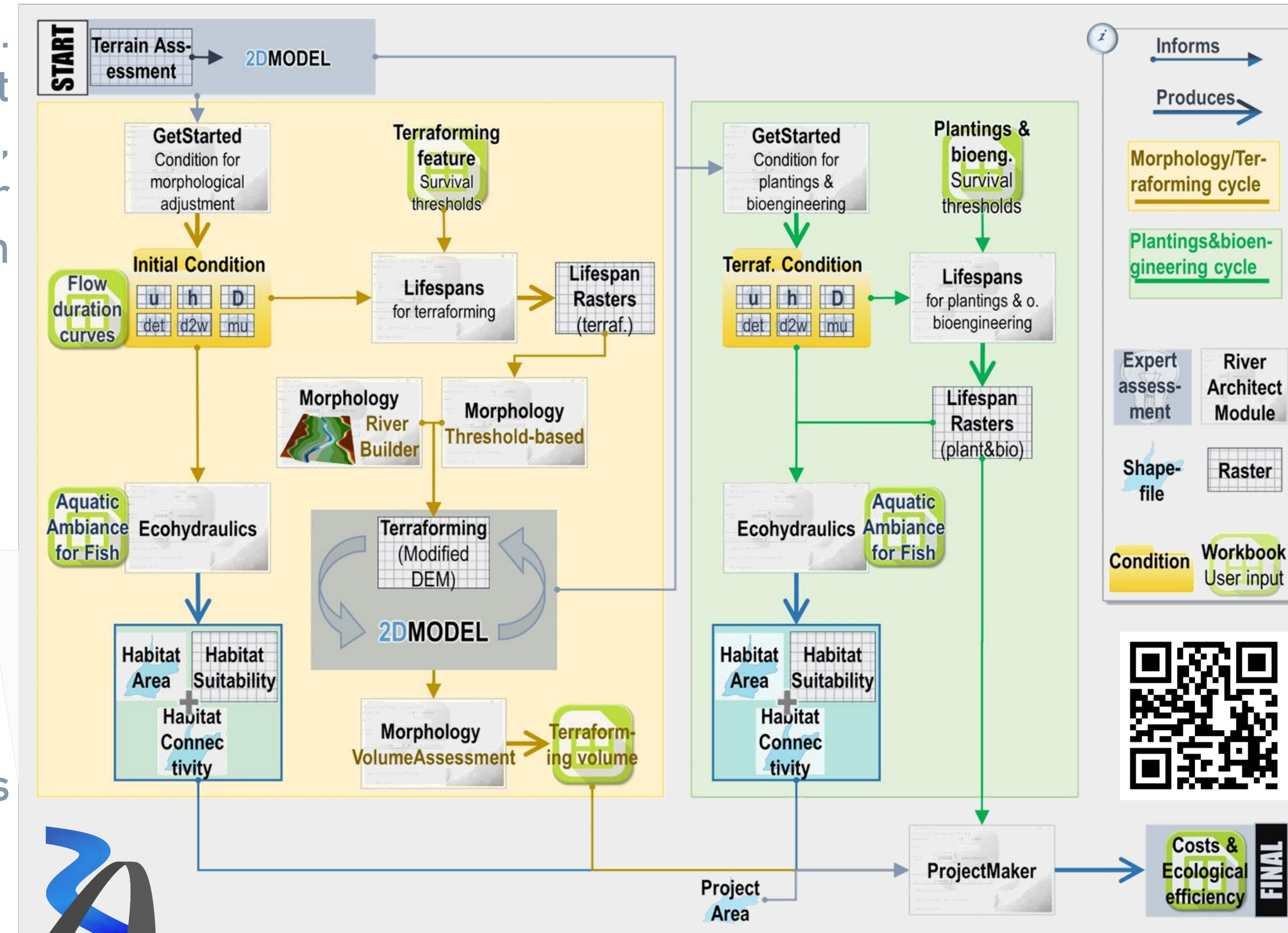
The design of River restoration and habitat enhancement involve geomorphologists, biologists and engineers. Working individually, every expert creates conceptual river landscapes, aquatic habitat optimized for target species or structural longevity of hydraulic bioengineering features. In a team consisting of geomorphologists, biologists and engineers, we have developed a parameter-based river habitat enhancement concept together with political actors and private parties. The concept parameterizes input data to perform the following design steps (Schwindt & Pasternack (2018) :

- 1) Assess lifespans (Schwindt et al. 2019) of nature-based engineering⁶ features
- 2) Design & terraform to optimize nature-based engineering⁶ survivorship and aquatic habitat



- 3) Calculate gain in seasonal habitat area SHArea⁶ based on Habitat Suitability Curves⁶ of target fish species and lifespans
- 4) Iterate over steps 1) to 3) to optimize lifespans and ecological utility
- 5) Estimate construction cost and project efficiency “Cost per are unit gained in SHArea⁶”

The parametrization of input variables enabled us to develop a Python3-based software called River Architect that automates our ecological and sustainable river design concept (Schwindt & Pasternack 2018). The software comes along with detailed documentation (Wiki) and can be downloaded using *git* from <https://riverarchitect.github.io> . River Architect applies the above flow chart (adapted from Schwindt et al. 2020).

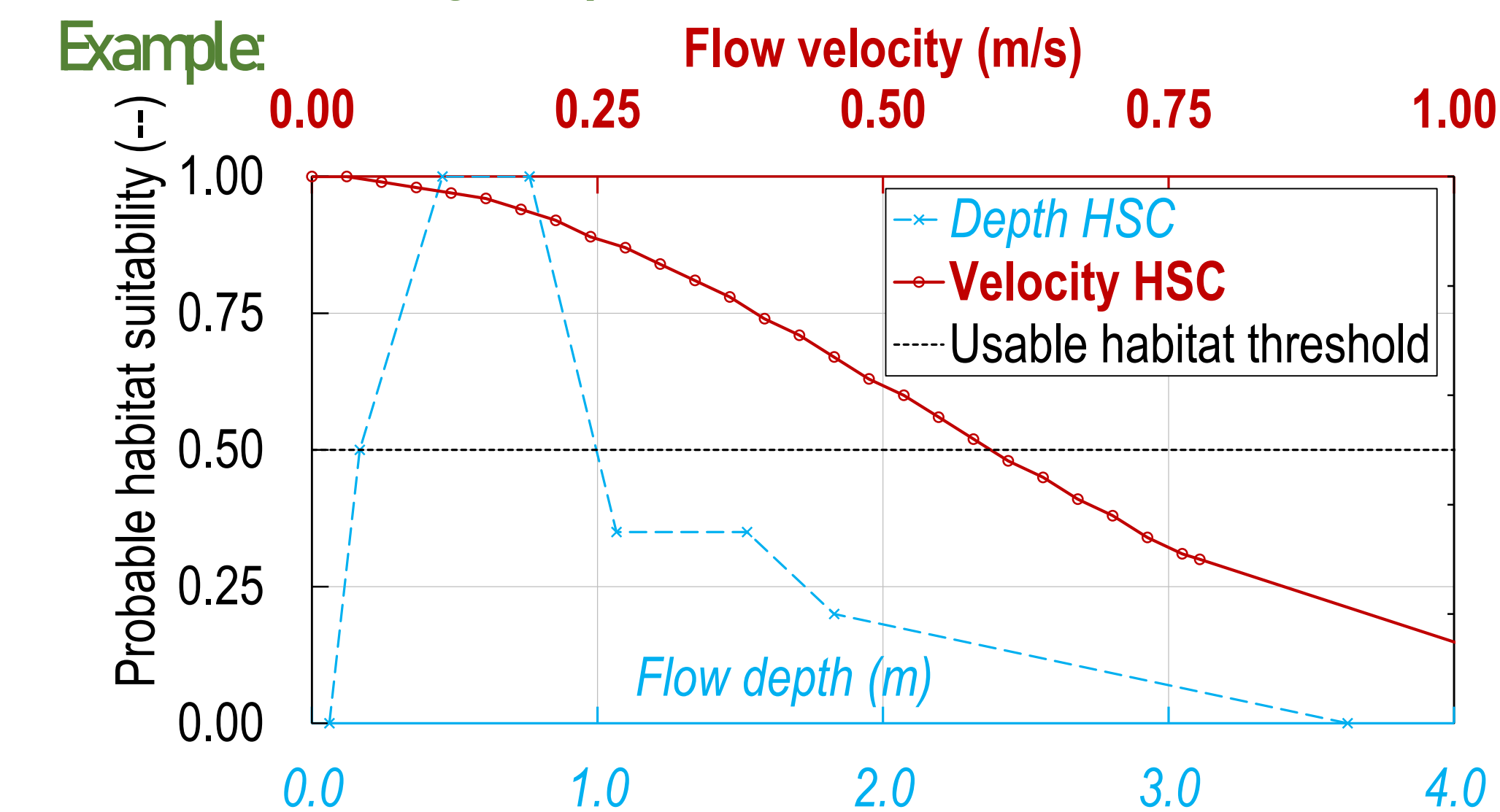


GLOSSARY

Nature-based engineering = Part-discipline of civil engineering that makes use of locally available, living materials and minerals substitute for rigid hydraulic engineering structures (Zeh, 2007). Examples



Habitat Suitability Curve = Indicator function of preferred hydraulic criteria (flow depth & velocity) by target fish species and their life stages 1=preference and 0=avoidance (Bovee 1986).

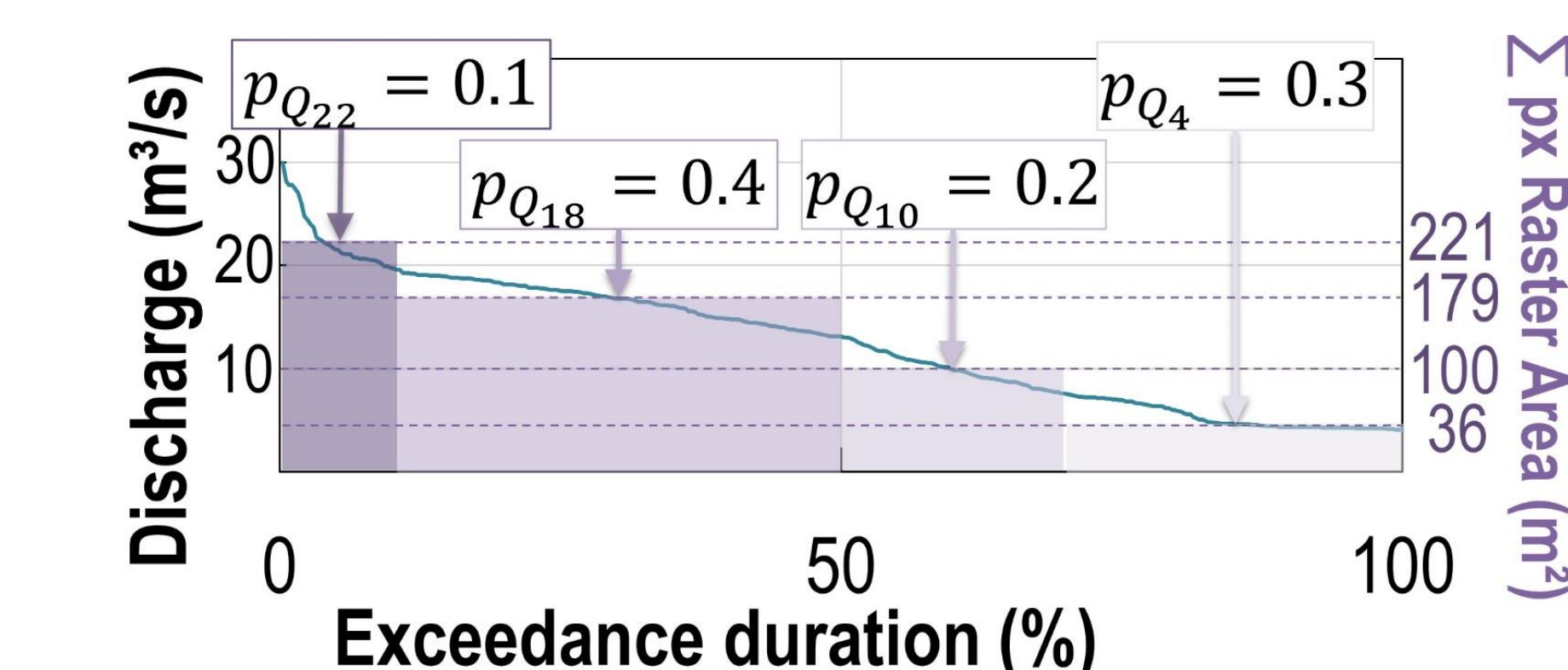


These curves define the Depth Habitat Suitability Index (DHSI) and Velocity Habitat Suitability Index (VHSI). The geometric mean of both constitutes the combined Habitat Suitability Index: $dHSI = \sqrt{DHSI \cdot VHSI}$

SHArea (Seasonal Habitat Area) =

$$\sum_{p_{Q_i}} [\sum_{px} (px(cHSI > \vartheta) \cdot A_{px})] \cdot p_{Q_k}$$

where $px(cHSI > \vartheta)$ denotes all raster pixels where c-HSI is higher than a threshold value ϑ ; A_{px} is the area (size) of pixels; p_{Q_k} is the relative duration (presence) of a raster during a fish season, associated with a discharge Q_k .



SHArea = 0.1·221+0.4·179+0.2·100+0.3·36=124.5m²
(source: Schwindt et al. 2020)

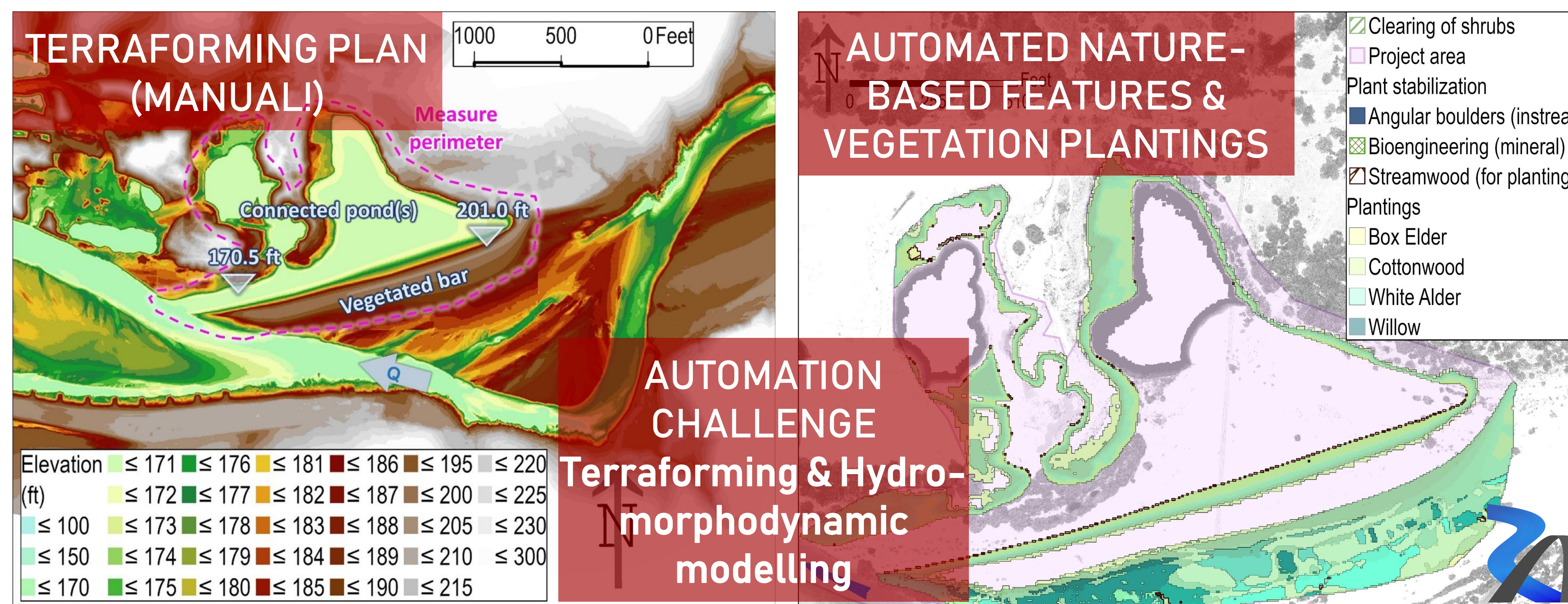
More about River Architect: Poster EP41C-2335 by K. Larrieu, Thursday 08:00-12:20

ACKNOWLEDGMENT

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RESULTS: SUSTAINABLE HABITAT WITH HALF-AUTOMATED DESIGN

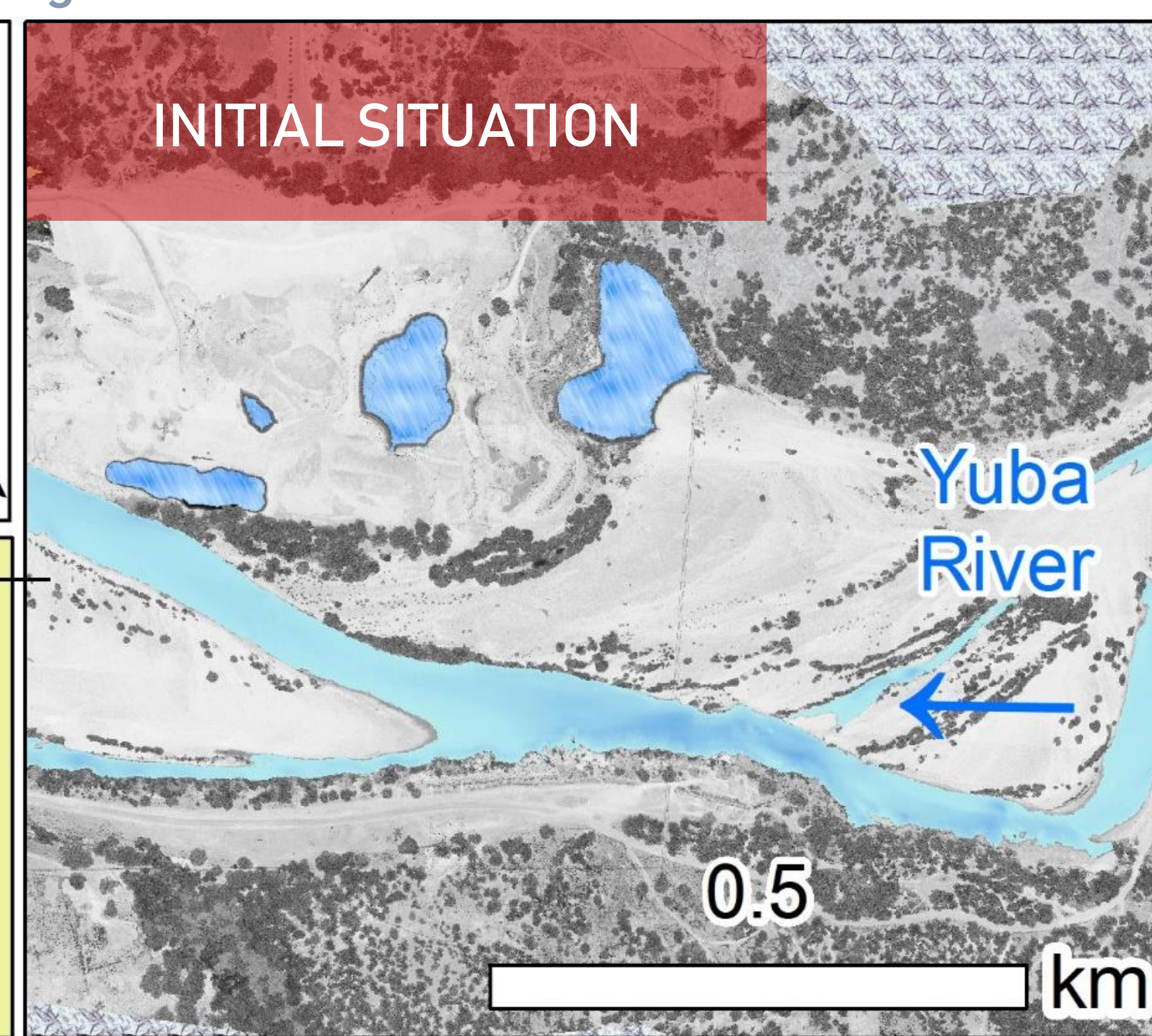
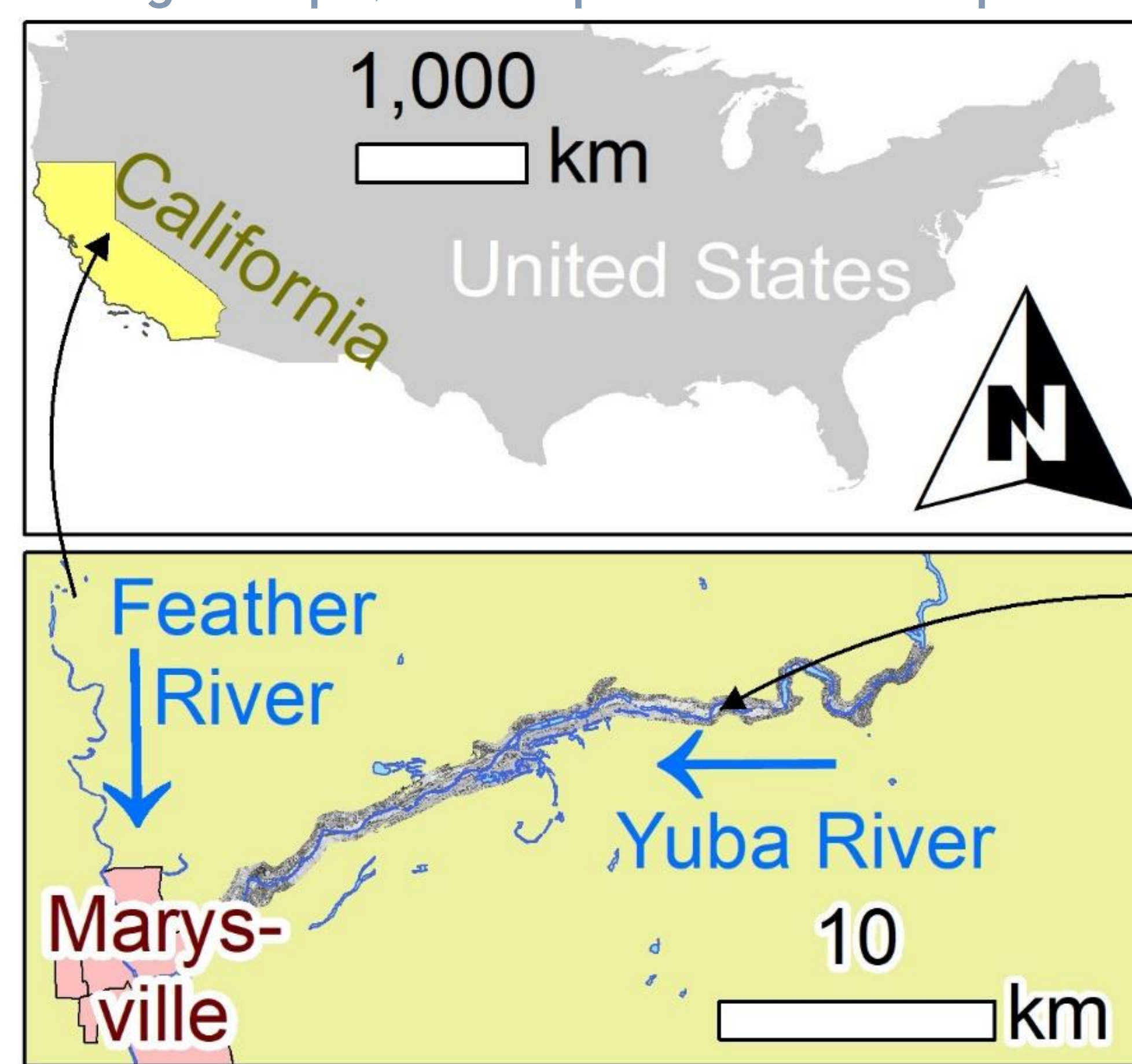


Construction costs			
Position	Quantity	Unit	Costs (US \$)
Terraforming (excavation dominates)	185,144	m³	\$5,569,486.56
Vegetation Plantings	1,216,515	m²	\$1,351,530.52
Stabilization of Vegetation Plantings	div.	div.	\$377,283.67
Bioengineering (other)	3,642	m²	\$686,070.00
Infrastructure improvements	--	m¹	--
Support and Maintenance Features	--	--	--
Civil engineering	20.0	%	\$1,597,080.02
Fees and Licensing	51.5	%	\$4,112,481.04
Estimated Total Costs			\$12,518,689.66
Net Gain in Seasonal Habitat Area (SHArea)	435,219	m²	\$12,518,689.66
Cost per m² SHArea	1.0	m² gain in SHArea	\$28.76

Discharge	Relative seasonal exceedance	Usable Area	Time-weighted Area
(m³/s)	(% Feb-June)	Before	After
2284.8	0.02	114,343	77,854
1713.6	0.05	124,226	110,023
965.7	0.34	168,460	123,767
325.5	2.93	7,088	84,509
169.4	12.15	3,895	155,936
141.6	17.54	3,847	519,169
113.3	35.47	4,562	534,920
97.8	40.44	5,436	534,872
85.0	46.02	5,815	531,349
63.9	56.54	7,019	516,307
63.6	56.66	7,046	516,100
56.6	60.19	7,852	511,132
42.5	71.94	11,182	500,961
38.8	76.59	14,767	483,158
28.4	84.53	19,178	463,240
26.3	86.83	20,437	446,834
24.9	87.59	21,132	440,585
23.1	88.91	22,041	432,789
20.7	97.31	23,073	421,387
17.6	98.14	24,263	403,275
15.0	99.80	24,945	26,403
SHArea Σ			10,736
			445,955

STUDY SITE

A 37.5-km stretch of the Yuba River has been identified for habitat enhancement for anadromous Chinook salmon (rearing from February to June), which is listed as threatened species under the federal Endangered Species Act. The dynamic cobble-gravel bed river is characterized by mean grain sizes of approximately 0.04m to 0.3m, an average wetted baseflow (25m³/s) width of 59.4 m and an average channel slope of 0.17%. The Yuba River has been in the focus of research on sediment and habitat dynamics since 1999. The research products include hydrodynamic parameter and topographic change maps, which provide a solid planning base for habitat enhancement.



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